WATER RESEARCH COMMISSION

June 2012

The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Wastewater treatment

Towards improved removal of ammonia-nitrogen from secondary sewage effluent

A WRC study investigated South African clinoptilolite for the removal of ammonia-nitrogen from secondary sewage effluent towards improved pollution control.

Removal of ammonia-nitrogen

Ammonia-nitrogen discharged into the water environment accelerates eutrophication of rivers and dams and dissolved oxygen depletion in receiving waters. It is toxic to fish at low concentration levels (0,2 mg/ℓ) and its removal can be important for activities such as fish farming, where a high production of the water is recycled.

Removal techniques

The current discharge requirement of ammonia-nitrogen in secondary sewage effluent is 10 mg/ℓ however; municipal biological treatment plants find it difficult at times to comply to these standards. Current removal techniques include selective ion-exchange using clinoptilolite, biological nitrification and denitrification, liming the pH to 11 followed by air (or steam) stripping, breakpoint chlorination followed by treatment with activated carbon as well as treatment in algal ponds.

Local clinoptilolite

Selective ion-exchange using a locally occurring, natural zeolite called clinoptilolite is a suitable material for ammonia-nitrogen removal from secondary sewage effluent. However, prior to this study there had been no specific local studies on the performance of this material. This technology could be an effective low-cost technology for the final polishing of secondary sewage effluent.

Development of design criteria

South African clinoptilolites were characterised and the efficiency of powdered clinoptilolite was determined for the removal and ammonia recovery from spent regenerant. This was followed by the evaluation of the performance of clinoptilolite on laboratory and pilot scale plants for the removal of ammonia-nitrogen from secondary effluent. The process design criteria were established and the established costs of the process determined.

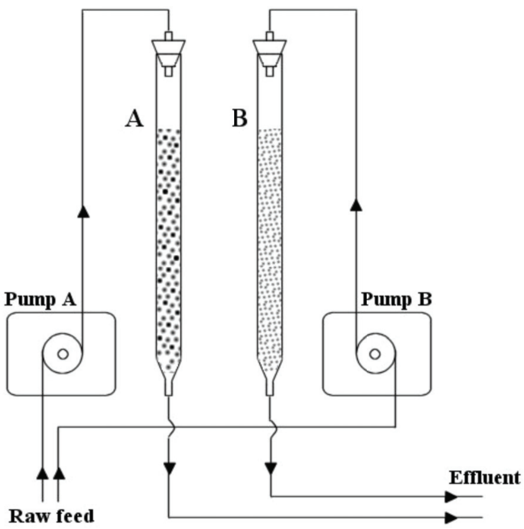
Characteristics of South African clinoptilolites

South African clinoptilolites (Pratley and Heidelberg) consisted mainly of clinoptilolite with traces of cristobalite low, orthodase high, quartz, muscovite and a relatively high concentration of heavy metals and rare earth elements. Total exchange capacity of the Pratley clinoptilolite is slightly lower than that of the overseas Hector clinoptilolite, but has about the same capacity.

In turn, the bulk and particle size of the South African clinoptilolites are higher than that of the overseas version. The surface area of the South African materials is low, however. In addition, the Heidelberg and Hector clinoptilolites appear to be more friable than similar products. Attrition losses of the Pratley clinoptilolite were significantly less than that of the Heidelberg and Hector clinoptilolites. Higher pH of the regeneration solution affects attrition adversely. Adsorption of ammonium ions on clinoptilolite fit both the Langmuir and Freundlich isotherms to some or other degree.

Efficiency of powdered and granular clinoptilolite for ammonia-nitrogen removal

Experimental data correlates well with model calculations. Ammonia-nitrogen could be reduced in secondary effluent with unconditioned and conditioned clinoptilolite (Pratley 1 and Pratley 2) for different doses with the expected different effluent quality. The process becomes uneconomical when high dosages are used.



The experimental laboratory-scale model

Performance of clinoptilolite on pilot scale

Pilot studies have shown that between 165 and 175 bed-volumes of product water could be produced when the feed ammonia-nitrogen concentration was approximately 16 mg/l. most of the ammonia-nitrogen could be removed from the clinoptilolite with regenerant. Potassium, calcium and magnesium ions that are removed with the ammonia-nitrogen in secondary effluent could also be effective removed. A backwash would be required prior to regeneration to successfully remove ammonia-nitrogen.

Process design criteria and costs

Process design criteria for a full-scale plant has been successfully derived from pilot studies to produce water that can be discharged to the water environment. Design options for ammonia-nitrogen removal are suggested.

The effluent from the secondary clarifiers is filtered through a sand filter to protect the clinoptilolite bed from plugging. The spent regenerant can either be chemically/physically or biologically treated for ammonia removal to recover the regenerant for reuse. More work should be conducted to determine the efficiency of biological regeneration. Chemical/physical treatment of the spent regenerant has been well researched and ammonia-nitrogen can be recovered as a fertilizer in the process.

Capital cost

The estimated capital cost for 50 and 100 m^3/day plants with and without NH_3-N recovery as well as the estimated operational costs with the typical lifespan of an ion-exchange plant of approximately 15 years were calculated and are included in the final report.

Further reading:
To obtain the report*, Evaluation of a South African clinoptilolite for the removal of ammonia-nitrogen from secondary sewage effluent for pollution control* (**Report No. 1658/1/11**) contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.